

Universes with and without a center

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Abstract

Two types of universe, with and without a center, are discussed; and their implications for the observed cmb (cosmic microwave background radiation) dipole are described. Theorems useful for understanding the cause for a cmb dipole are presented.

I. INTRODUCTION

There are two types of cosmology even in the realm of the Friedman universe, one with a center for expansion and the other without a center. The Hubble law, $\mathbf{v} = H_0 \mathbf{r}$, yields the relationship, $\mathbf{v}_2 - \mathbf{v}_1 = H_0 (\mathbf{r}_2 - \mathbf{r}_1)$ for any two galaxies with positions and velocities, \mathbf{r}_1 , \mathbf{v}_1 and \mathbf{r}_2 , \mathbf{v}_2 respectively, where $H_0 = 100 h \text{ km/s-Mpc}$ is the Hubble constant (with $h = 0.5 \sim 0.85$). For convenience of discussion, we assume the value of H_0 to be 70.0 km/s-Mpc in this article. This equation implies that every point appears to be the center of the expansion. In other words, both types of cosmology yield the same conclusion, as far as the Hubble law is concerned. However, the observed cmb dipole has different implications for the two types of cosmology and observational differences are discussed.

II. TWO TYPES OF COSMOLOGY

In the Friedman universe,

$$ds^2 = dt^2 - a(t)^2(dr^2/(1 - kr^2) + r^2d\theta^2 + r^2\sin^2(\theta)d\phi^2), \quad (1)$$

with an appropriate source, T^μ_ν , there are two types of interpretation for the radial coordinate, r .

I) B-type Universe

The universe resides on the surface of an expanding balloon (B for balloon). The center does not exist in the universe. (It exists outside the universe.) The coordinate origin can be chosen at any point but there is no special significance for such a choice. The Hubble law is naturally built into the framework. There are no velocities associated with individual points of the universe, but the relative distance and relative velocity of any two points increase with the expansion of the balloon. Apparently, many physicists subscribe to this type of universe as their image.

II) C-type Universe

The origin of the radial coordinate has a physical meaning as the point where the expansion started. Each point of the universe has a Hubble flow velocity relative to the origin that is proportional to the distance from the origin (C for center). As discussed in the introduction, the linearity of the Hubble law makes every point in the universe look like a center for the expansion of the universe, even though the center of the universe exists.

I will discuss the implications of the observed cmb dipole for cosmologies of B-type and C-type. An important point is how to discriminate the two types of cosmology observationally.

III. THE CMB DIPOLE IN A B-TYPE UNIVERSE

Each point is equivalent relative to a distant cmb emitter and there is no cmb dipole at any point except possibly that due to a peculiar velocity in a cluster. Let me state this in the form of a theorem.

Theorem 1 *No point in a B-type universe observes a cmb dipole.*

Proof. *This is obvious because of symmetry between opposite directions.* ■

However, the next theorem might be a surprise to some.

Theorem 2 *A peculiar velocity at a point in a B-type universe does not produce a cmb dipole.*

Proof. *Let an object at point A have a peculiar velocity \mathbf{v} . There is a point $A_{\mathbf{v}}$ in the direction of \mathbf{v} which has a velocity \mathbf{v} relative to A. Peculiar velocities at points A and $A_{\mathbf{v}}$ have the same motion, and point $A_{\mathbf{v}}$ has no cmb dipole by Theorem 1, so a peculiar velocity at A does not observe a cmb dipole. In order to help visualize this, let us imagine a structure extended from $A_{\mathbf{v}}$ to A. Since a structure does not expand along with the universe, all points on it should observe the same cmb dipole, a vanishing cmb dipole in this case. A peculiar velocity at point A and at a point on the extended structure coinciding with A have the same velocity and the same location, so they should have the same cmb dipole. Since the point on the extended structure has zero cmb dipole, the theorem has been proved.* ■

IV. THE CMB DIPOLE IN A C-TYPE UNIVERSE

In this universe, each point is moving away from a fixed point within it, the center, with velocity \mathbf{v} , which may be called the Hubble flow velocity. The velocity is written in terms of the distance \mathbf{r} of the point from the center as

$$\mathbf{v} = H_0 \mathbf{r}, \tag{2}$$

where H_0 is the Hubble constant.

Theorem 3 *A point in a C-type Universe observes a cmb dipole \mathbf{v} , where \mathbf{v} is the Hubble flow velocity.*

Proof. *Let us denote the velocity of a cmb emitter in the direction of the Hubble flow velocity by \mathbf{V} . From the size of the present universe, V is close to speed of light, c . The relative velocity of the cmb emitter and an observer with Hubble flow velocity \mathbf{v} is given by*

$$(V - v)/(1 - \frac{Vv}{c^2}) = V - v + \frac{(V - v)V}{c^2}v = V - v + v \quad (3)$$

to linear approximation in v . Here, we used

$$V^2/c^2 \approx 1 \quad (4)$$

A cmb emitter in the direction opposite to the Hubble flow should have velocity $V - 2v$ in order to reach the observer at the same time as the one from the opposite direction. The relative velocity in this direction is

$$(V - 2v + v)/(1 + \frac{(V - 2v)v}{c^2}) = V - v - \frac{(V - v)(V - 2v)}{c^2}v = V - v - v \quad (5)$$

The difference between Eq (3) and Eq. (5) shows a cmb dipole \mathbf{v} , which is identical to the Hubble flow velocity. ■

The following shows the effect of a peculiar velocity in a C-type Universe.

Theorem 4 *A peculiar velocity in a C-type universe yields a cmb dipole with velocity equal to the vector sum of the Hubble flow velocity and the peculiar velocity.*

Proof. *The proof is very similar to that of Theorem 2 in the previous section. The only difference is the nature of the rest of the Universe concerning the cmb dipole. The motion of a peculiar velocity, \mathbf{v}_p , at a Hubble flow velocity, \mathbf{v} , is identical to that at a Hubble flow velocity, $\mathbf{v} + \mathbf{v}_p$. Since the latter has a cmb dipole, $\mathbf{v} + \mathbf{v}_p$, a peculiar velocity contributes to a cmb dipole, \mathbf{v}_p . If necessary, consider an extended structure from the location of the Hubble flow velocity, $\mathbf{v} + \mathbf{v}_p$, to the location of a Hubble flow velocity, \mathbf{v} . ■*

V. SUMMARY AND CONCLUSION

Summarizing the theorems in the previous sections, I can state the following.

1) In a B-type universe, nobody observes a cmb dipole. Not even a peculiar velocity yields a cmb dipole.

2) In a C-type universe, every body observes a cmb dipole which is equal to its Hubble flow velocity. Away from the center, the magnitude of the cmb dipole increases with distance from the center. With a peculiar velocity presenting, the cmb dipole is the vector sum of the Hubble flow velocity and the peculiar velocity. At the center, the cmb dipole is zero and only one point in the universe has such a property. If a cmb dipole and a peculiar velocity coincide with each other, one has to reside at the center.

Now that a cmb dipole has been observed[1],[2], one has to conclude that there should exist a center of the universe.

II) If the observed cmb dipole and the peculiar velocity of the solar system coincide, as is assumed among some physicists, the solar system must reside at the center of the universe. As explained elsewhere[3], this is not true. The solar system moves towards the Virgo cluster

I) A B-type universe is not compatible with the observation. A C-type universe must be accepted. T[4],[5],[6], but the Virgo cluster moves towards the Great Attractor[7] (hereafter called GA).

III) The observed cmb dipole is the vector sum of the Hubble flow and peculiar velocities. It is a measure of the effective distance from the center of the universe. It is remarkable that the measurement of the cmb dipole is nothing but the measurement of this distance.

IV) The magnitudes of the observed cmb dipole and the above mentioned peculiar velocities are relatively small. This means that we are relatively close to the center of the universe.

VI. THE POSITION OF THE CENTER

The observed cmb dipole for blue shift is expressed as[1],[2]

$$v(dipole) = 371 \pm 0.5 \text{ km/s}, \quad l = 264.4 \pm 0.3^\circ, \quad b = 48.4 \pm 0.5^\circ, \quad (6)$$

while the peculiar velocity of the solar system towards the Virgo cluster is estimated to be[4],[5],[6],

$$v_1 = 415 \text{ km/s}, \quad l = 335^\circ, \quad b = 7^\circ \quad (7)$$

or

$$v_1 = 630 \text{ km/s}, \quad l = 330^\circ, \quad b = 45^\circ. \quad (8)$$

The location of the Virgo cluster is

$$v = 1050 \pm 200 \text{ km/s}, \quad l = 287^\circ, \quad b = 72.3^\circ. \quad (9)$$

The infall velocity of the Virgo cluster towards the GA is given as[7]

$$v_{in} = 1000 \pm 200 \text{ km/s} \quad (10)$$

and the GA is located at

$$v(GA) = 4200 \text{ km/s}, \quad l = 309^\circ, \quad b = 18^\circ \quad (11)$$

or

$$v(GA) = 3000 \text{ km/s}, \quad l = 305^\circ, \quad b = 18^\circ. \quad (12)$$

The peculiar velocity of the Virgo cluster relative to the GA is expressed as

$$v_2 = 1000 \pm 200 \text{ km/s}, \quad l = 310.9 \pm 0.4^\circ, \quad b = 4.6 \pm 2.8^\circ \quad (13)$$

for Eq. (11), or

$$v_2 = 1000 \pm 200 \text{ km/s}, \quad l = 307.2 \pm 1.6^\circ, \quad b = 1.6 \pm 3.0^\circ \quad (14)$$

for Eq. (12).

With this information, the position of the center, v_c , can be calculated as

$$v(GA) - v_c + v_1 + v_2 = v(dipole) \quad (15)$$

and hence

$$v_c = v(GA) + v_1 + v_2 - v(dipole). \quad (16)$$

The author estimated the location of the center of the universe to be

$$v_c = 5012.2 \pm 205 \text{ km/s}, \quad l_c = 315.3 \pm 0.2^\circ, \quad b_c = 1.7 \pm 0.3^\circ \quad (17)$$

or

$$v_c = 5082.5 \pm 208 \text{ km/s}, \quad l_c = 315.0 \pm 0.2^\circ, \quad b_c = 6.2 \pm 0.3^\circ \quad (18)$$

for the case of Eq. (11) for the GA, where the two cases correspond to the velocities of the solar system, Eq. (7) or Eq. (8). For the case of Eq. (12) for the GA, one gets

$$v_c = 4097.6 \pm 200 \text{ km/s}, \quad l_c = 310.7 \pm 0.2^\circ, \quad b_c = 9.4 \pm 0.4^\circ \quad (19)$$

or

$$v_c = 4224.1 \pm 194 \text{ km/s}, \quad l_c = 310.4 \pm 0.2^\circ, \quad b_c = 14.6 \pm 0.6^\circ \quad (20)$$

for the two solar system velocities. There are errors in the numerical estimate in the previous reference[3], they should be corrected by the numbers in this article. One notices that the direction obtained for the center is close to that of Centaurus A,

$$l(\textit{CentaurusA}) = 309.51587^\circ, \quad b(\textit{CentaurusA}) = 19.41732^\circ.[.] \quad (21)$$

Compare this to the direction in the solution above, Eq. (20).

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